Abstract

Prior research on information literacy instruction in engineering graduate programs rarely considers course instructor perspectives, and instead only uses student feedback to evaluate the efficacy of information literacy instruction. This study documents the authors’ efforts to evolve the library curriculum to motivate student learning and meet the course needs. Data collected from the student survey and course instructor questionnaire found that most students reported that the instruction was engaging and satisfying, but evaluations of the usefulness of the instruction were mixed. The course instructor was satisfied with the students’ overall work in information gathering though found their project reports unsatisfactory in terms of report writing and critical thinking. The findings shed light on student needs and faculty expectations of engineering project-based graduate courses.

Keywords: Information literacy, Engineering, Graduate program, Instructional design, Pedagogy

Recommended citation:

**Introduction**

Information literacy instruction has become an integral part of academic curricula at many post-secondary institutions to support their teaching and learning missions. Due to today’s information environment, academic librarians have switched their work focus from information access to information skills and act as educators committed to student learning (Bennett, 2009; Bundy, 2004). Bundy (2004) points out that “Information literacy is an issue for librarians but it is not a library issue” (p. 7) and that all university teaching staff are responsible for information literacy. Bundy further argues that academic librarians must still take the lead in information literacy due to their professional expertise. The Association of College and Research Libraries (ACRL) *Environmental Scan 2019* recognizes that “Librarians continue to partner with campus constituents and to be responsive to curricular developments and new pedagogical approaches on campus” (Association of College and Research Libraries, 2019, p. 10). In addition, ACRL’s *Standards for Libraries in Higher Education* provides academic librarians with guidance on instructional design and pedagogies, such as Performance Indicator 3.3 “Library personnel model best pedagogical practices for classroom teaching, online tutorial design, and other educational practices” and 3.4 “Library personnel provide appropriate and timely instruction in a variety of contexts and employ multiple learning platforms and pedagogies” (Association of College and Research Libraries, 2018, p. 11). Considering the ACRL standards above, the present study aims to understand engineering graduate student information needs, learning preferences, and faculty expectations associated with course-integrated information literacy instruction in a graduate engineering curriculum.

This study focuses on information literacy instruction within the Mechanical Engineering Master of Engineering (M.Eng.) Program, Department of Mechanical & Materials Engineering (MME), at the University of Western Ontario (UWO) in Ontario, Canada. As a founding member of the U15, Canada’s most prestigious research universities, UWO consists of 12 faculties and approximately 32,000 full-time undergraduate and graduate students (University of Western Ontario, n.d.-a). The Mechanical Engineering M.Eng. Program trains future engineers with the necessary skills for their professional careers and requires students to complete ten half-courses (a half-course is a course whose duration is one academic term) or eight half-courses plus an M.Eng. Project (Mechanical and Materials Engineering, 2021). Specifically, the program promises to serve as “a great preparation strategy” for those pursuing registered professional engineer (P.Eng.) status in Ontario, Canada (Mechanical and Materials Engineering, n.d.). In addition, UWO’s enrollment of international students is as high as 68.7% of the total full-time enrollment of engineering graduate programs during the 2019-2020 academic year (University of Western Ontario, n.d.-b). Receiving the M.Eng. education allows international students to gain a vital Canadian qualification that is important for employment and subsequent P.Eng. registration.
The courses involved in this study are MME 9617 Energy Conversion and MME 9641 Thermal Systems Engineering, both of which are elective courses offered in UWO’s Winter academic term from January to April. Although these courses focus on different fields of mechanical engineering, they share similar assessment deliverables, and so include the same library curriculum and pedagogy. For many years, the course instructor and the librarian, the authors of this study, met after each iteration and discussed student performance based on their project reports and what improvements could be made the following year. The common issues included: (a) most students’ project reports did not meet the instructor’s expectations, and (b) many students attended the library sessions unaware of the purpose for acquiring information skills and were therefore not fully engaged in class. After the iteration of 2018-2019, the authors decided to conduct this study during the 2019-2020 academic year. There was a total of 31 students enrolled across the two graduate courses offered by the same course instructor, a faculty member and co-author on this paper. Based on the numbers enrolled, the present study is a small-scale case study.

**Literature Review**

Rapid knowledge updates and technological changes require engineers to engage in life-long learning throughout their careers. According to Smerdon (1996), engineering practitioners must keep learning to stay competitive in their fields, replacing half of their professional skills every few years, based on the “half-life of an engineer’s technical skills” (p. 4) estimated by experts. As the speed of technological advances in engineering fields increases, engineers will need to update their technical skills even more frequently (Hoschette, 2010; National Academy of Engineering, 2012, 2018). The Information Literacy Standards for Science and Engineering/Technology also states that science and engineering disciplines are “rapidly changing” and that information literacy is important, not only for “students in science and engineering/technology disciplines who must access a wide variety of information sources and formats that carry the body of knowledge in their fields,” but also for “the practicing scientist and engineer that they know how to keep up with new developments and new sources of experimental/research data” (American Library Association, 2006, para. 1). The Information Literacy Standards for Science and Engineering/Technology defines information literacy as:

> a set of abilities to identify the need for information, procure the information, evaluate the information and subsequently revise the strategy for obtaining the information, to use the information and to use it in an ethical and legal manner, and to engage in lifelong learning. (para. 1)

Professional engineers in Canada must be licensed by the provincial and territorial engineering regulatory bodies where they are employed, and the regulatory body in Ontario is Professional Engineers Ontario (PEO) (Engineers Canada, n.d.). PEO offers guidelines for engineers to follow in their practice and for the public to learn about engineering practice standards (Professional Engineers Ontario, n.d.). The use of information skills is described in relevant sections of the Guideline for Professional Engineering Practice by PEO (Professional Engineers Ontario, 2020):
10.5 Report Writing: All engineering reports need to contain: …references to legislation, standards, or guidelines that are relevant to the work…The practitioner must assess the information gathered during investigations and analyses to determine if it is sufficient to form a conclusion (p. 13).

10.11 Data Gathering at Beginning of Project: A search of available technical literature, such as journals and trade magazines, for best practices and experiences of other practitioners engaged in similar projects can be useful. Practitioners should also become familiar with applicable federal and provincial regulations and, for certain kinds of engineering work, municipal by-laws (p. 16).

Several studies have reported on the expectations of engineering firms with respect to information skills possessed by engineers or engineering graduates, and suggest post-secondary institutions are well-positioned to help engineering students develop these essential skills. Engineering students with information skills can transition more easily into the corporate environment than those without. Rodrigues (2001) investigated research-related activities conducted by engineers in industry and found new engineers are often assigned to locate specific data and business information for certain products and processes. Rodrigues remarks that engineering firms usually have limited or no library services while academic institutions offer sufficient library resources and support, so that engineering students should make use of academic library resources to acquire the information skills needed for their future careers. A survey and its follow-up studies were conducted on library services at Engineering News Record’s Top 500 Design Firms, and their data were published in 2004 and 2017, respectively, and their findings disclose: a majority of participating firms (74.4% in 2004; 86.6% in 2017) do not hire a librarian holding a masters in library science or its equivalent, so most engineers in these firms must find information on their own; and, a high percentage of participating firms (86.2% in 2004; 83.5% in 2017) do not subscribe to any databases (Napp, 2004, 2017). Napp concurs with Rodrigues’ point that engineers should learn information skills while receiving post-secondary education. Academic librarians should focus on teaching transferrable skills rather than specific library resources, as available collections in academia and industry can differ (Waters et al., 2012).

A variety of factors can contribute to the efficacy of information literacy instruction. Carroll (2020) points out that graduate students in science, technology, engineering, and mathematics (STEM) usually lack information literacy skills with primary literature. Still, they tend to overestimate their skills, which affects their motivation to engage with information literacy instruction to acquire these core skills. Research shows that the Dunning-Kruger effect exists in the information literacy instruction field (Mahmood, 2016; Molteni & Chan, 2015), which is “a lack of metacognitive skills among less skilled participants” (Kruger & Dunning, 1999, p. 1131). Information retrieval is critical in STEM, but two challenges exist in teaching information retrieval: one is to “identify instructional goals,” and the other is to “establish criteria for judging teaching effectiveness” (Cruickshank, 2019, p. 85). According to Cruickshank, librarians usually teach database searching by their pre-designed example questions with expected good results from the databases, which can be problematic in helping students acquire real-world information retrieval skills. Although Google and Google Scholar are not
comparable to subscription-based databases in terms of functionality and discoverability, many engineering students prefer these free web search engines due to their familiar and easy-to-access interfaces (Bohémier, 2019; Lalwani et al., 2018). Regarding the correlation between student information literacy level and the amount of relevant library training, one study reports that those with more library training did not show better performance than those without (Johnson & Mentzer, 2019). A similar observation that more library instruction did not bring students additional learning gains is reported in another study investigating students across disciplines other than STEM, and the author concludes that “experience does not equal effectiveness” because engaging instructional strategies are vital to student learning and academic growth (Stec, 2005, p. 97).

Academic librarians have applied learning principles or pedagogical approaches to their teaching practices to facilitate student learning. Transformative learning has been adopted by the Framework for Information Literacy for Higher Education by ACRL, in the form of threshold concepts, as the professional guideline for academic library instructors (Association of College and Research Libraries, 2015). Hooper and Scharf (2017) suggest that librarians should prioritize their content for their limited class time by breaking down students’ misconceptions about information resources or the library while leaving easy-to-understand content to students’ self-learning. Plus, threshold concepts integrated into information literacy instruction should not be limited to the six recommended by ACRL but should also include those subject-specific and profession-related ones to help students succeed in their fields (Alpi & Hoggan, 2016).

Constructivism, also incorporated into information literacy instruction, helps students learn through “authentic” active learning experiences where the learning process “moves from experience to knowledge and not the other way around” (Cooperstein & Kocevar-Weidinger, 2004, p. 141). Furthermore, studies document that active learning activities based on constructivist learning theory have been incorporated into information literacy instruction research and practice (Cooperstein & Kocevar-Weidinger, 2004; Kappers, 2016; Korber & Shepherd, 2019; Riehle, 2012).

The above literature review confirms that engineering graduate students must acquire essential information skills to thrive in their current academic studies and future careers. A variety of factors, namely teaching approaches and student metacognitive skills, can contribute to the efficacy of information literacy instruction. Some of the literature reviewed relies on students’ feedback in evaluating the effectiveness and engagement of library instruction for engineering courses, while there is little prior work that also integrates course instructor perspectives, particularly at the graduate level. Thus, the current study contributes to filling this gap in the literature.

**Background**

The course-integrated information literacy instruction for MME 9617 and MME 9641 is aligned with the course learning outcomes, which are shown below as presented in the course outlines (Savory, 2020a, 2020b):
• To improve your knowledge of a specific area of energy conversion analysis (MME 9617) and thermal systems engineering (MME 9641), including emerging technologies.

• To develop your skills in critical analysis of published engineering research work, synthesis of those findings and the drawing of your own evidence-based conclusions from those studies.

• To develop your skills in technical report writing, including report structure and consistent and accurate referencing of previously published papers.

Although the two courses focus on different aspects of mechanical engineering products, processes, and practices, they share major assessment deliverables: students conduct a literature review project individually on their chosen topic, submit a progress report, and a final term paper. Students must conduct a critical review based on a minimum of 10 papers, including at least five peer-reviewed journal articles with others being academic theses or conference papers. The course instructor expects student project reports in both courses to be completed as a critical appraisal of the published work on their chosen topic. The course project outline provides the required report structure and what should be included in each section. Students should also pay attention to correctly citing published sources. Due to a majority of graduate students being international students and non-native English speakers, the course instructor does not require grammatically perfect reports, but wants the project reports to be clear and understandable. He particularly emphasizes the evidence of critical thinking as the crucial part of grading. Considering the above, the information literacy instruction for the two courses share the same curriculum and pedagogy.

For years, the course instructor has invited the librarian to work on instructional design related to information literacy that has resulted in a long-term faculty-librarian collaborative relationship. After each iteration, the course instructor updates the librarian about student performance based on their project reports, and they discuss possible improvements for future instruction. As a result, the librarian has been well aware of the course requirements and expectations.

The course instructor allotted three class times for library instruction for each course, and for many years the arrangements of these class times included one hands-on session and two follow-up class visits. The hands-on session was taught in the library’s instruction room in January, the second week of the term, for students to learn a variety of information literacy topics, including library resources, literature search strategies, information evaluation, literature review methods, and academic integrity and plagiarism. Then, in two follow-up class visits in February and March, the librarian would answer questions that students had in their literature review and paper writing.

After the 2018-2019 iteration, the librarian and the course instructor discussed how to improve the library curriculum to engage students in learning and help them achieve the course learning outcomes, as most student project reports were unsatisfactory and many students lacked interest or motivation in learning information literacy topics. As student motivation is closely associated with student learning and performance (Ambrose et al., 2010), several improvements were made to the library curriculum for the 2019-2020 iteration to provide students with a more engaging learning experience.
For the following iteration (2019-2020), the librarian revised the lesson plan, which consists of learning outcomes, session content, and preparatory work to help students better understand the purpose for the library instruction and the bigger picture. The preparatory work section included guidelines and resource links for students to prepare for the library sessions. Several learning activities were added or revised to make the library curriculum more relevant and meaningful. For example, prior to the hands-on session, students were required to find search terms for their project and to install Mendeley, a citation manager. In class, instead of using a librarian-chosen example, students searched for their own topic and imported related scholarly sources into Mendeley. So, students were encouraged to find and save relevant information sources during the first library session. This approach was chosen to engage students in library instruction and give them some confidence in the course project. In addition, the course instructor and the librarian co-taught the literature review topic using course-related examples to better connect library instruction to the course material. Thus, students could better understand the course instructor’s expectations of their literature review projects. The topic of academic integrity and plagiarism was moved to the second library session (previously, the first follow-up class visit) to release some class time in the first session to accommodate a newly added class activity on the literature review topic. Table 1 shows the different project activities and library sessions arranged throughout the term. The instructional design and pedagogical approaches for 2019-2020 are outlined in Figure 1. Table 2 lists the information literacy topics, preparatory work, and in-class learning activities.

Table 1. Timeline of project activities and library sessions

<table>
<thead>
<tr>
<th>Project Activities and Library Sessions</th>
<th>January–April 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Term Project Briefing</td>
<td>Week 1</td>
</tr>
<tr>
<td>Library Session #1</td>
<td>Week 2</td>
</tr>
<tr>
<td>Library Session #2</td>
<td>Week 5</td>
</tr>
<tr>
<td>Progress Report Due</td>
<td>Week 6</td>
</tr>
<tr>
<td>Librarian’s Follow-up Class Visit</td>
<td>Week 9</td>
</tr>
<tr>
<td>Final Report Due</td>
<td>Week 12</td>
</tr>
</tbody>
</table>

Figure 1. Outlines of instructional design and pedagogical approaches for 2019-2020

The library instruction for the 2019-2020 cohort was delivered face-to-face between January and early March 2020. In mid-March, the UWO moved all its courses online.
because of the COVID-19 situation. So, all the students in the winter term from January-April 2020 completed the second half of their courses through online learning. The library sessions were conducted at the Taylor Library’s Instruction Room, which offers collaborative learning features such that students can sit in groups and share the screens on their devices using wireless connections.

<table>
<thead>
<tr>
<th>Topics</th>
<th>Preparatory Work</th>
<th>In-Class Learning Activities</th>
</tr>
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</table>
| Literature Searching            | • Review the example on the Search Strategy Worksheet (library handout) regarding how to find search terms  
• Find main concepts and keywords for the research topic you picked.  
• Fill out the blank table of the Worksheet | • Build a search strategy with appropriate search terms and Boolean operators  
• Apply search strategies effectively in core information resources  
• Find relevant information sources for your project. |
| Citation Management             | Install Mendeley, the reference manager:  
• Create a free account with Mendeley from:  
  https://www.mendeley.com/  
• Download Mendeley Desktop, Web Importer, and Citation Plugin from:  
  https://www.mendeley.com/download-desktop/  
• Sign into Mendeley Desktop and Web Importer on your laptop or mobile device | Use the Mendeley software throughout the session:  
• Create a folder based on your project or course  
• Import citations from various information resources to Mendeley, using the Web Importer or the citation exporting features in databases  
• Select or install the APA (American Psychological Association) citation style  
• Use the Word Plugin to generate in-text citations and the bibliography list in the Word document |
| Literature Review               | • Review the three journal articles assigned by the instructor  
• Review the library guide about how to do a literature review  
• Fill out the Synthesis Matrix (library handout) on your own  
• Bring the Synthesis Matrix to the session for class activities to reinforce your learning of this recommended way to conduct a literature review | • Students form groups of three or four and fill out a Synthesis Matrix for their group  
• The course instructor reviews the work done by the groups  
• The Class discusses how to review scholarly articles and evaluate their methodological quality (part of information evaluation content) |
| Information Evaluation         | • Think about your recent literature searches for your scholarly work (not limited to this course) and answer the following questions:  
  a) What information resources did you use for the searches, for example, Wikipedia, Google, journal sites, or databases, etc.? | • Learn information evaluation approaches  
• Compare commonly used information resources  
• Become familiar with resources to evaluate journals, such as Ulrich’s Periodical Directory, Journal Citation Reports, and conduct searches in these resources |
b) What were your criteria for information evaluation?
• Read the Evaluating Sources: General Guidelines & Evaluating Digital Sources webpages by Purdue Online Writing Lab

Avoiding Plagiarism
• Read the two news articles about a plagiarism case
• Visit the library guides/tutorials for relevant information: Plagiarism and Paraphrasing
• Case studies: What did the plagiarist do? When and where? What were the reasons for him to plagiarize? What were the consequences?
• Group activity & Class discussion: Discuss ten scenarios about information use, acceptable or unacceptable, and how to avoid plagiarism

Methods

The human research ethics application for this study was approved by the Office of Research Ethics, UWO, on April 8, 2020.

Recruitment

Research participants were the students enrolled in MME 9617 and MME 9641 in the Mechanical Engineering M.Eng. Program during the 2019-2020 academic year. The faculty author, who taught both courses, provided his answers to the research instrument used for the course instructor.

Research Questions

The research questions of this study are:

• What are the information needs of engineering graduate students in a project-based course?
• To what extent did students find the information literacy instruction useful and engaging?
• To what extent did student project reports meet requirements and other expectations for their course project paper?
• How can the course-integrated information literacy instruction be improved?

Research Instruments and Data Collection

An online student survey was developed and administered in Qualtrics using UWO’s institutional license to learn about student information needs and solicit feedback on their learning experiences with the library instruction. The survey was administered during April–May 2020, at the end of the UWO’s Winter term from January–April 2020. The survey was disseminated to the students in both courses and did not distinguish which class a student respondent was attending. See Appendix 1 for the student survey.
A questionnaire was developed for the course instructor to analyze the students’ performance and formulate his perspectives on library instruction. Students’ performance was investigated in an aggregate form based on their project reports. See Appendix 2 for the course instructor questionnaire.

**Results and Discussion**

**Online Student Survey**

There were 18 valid student survey responses from 31 students enrolled in the two courses during 2019-2020, giving a response rate of 58%. This response rate is satisfactory, considering the data collection stage was during the unprecedented COVID-19 pandemic.

The first three survey questions asked about students’ backgrounds, including their currently enrolled program, language proficiency (native or non-native English speaker), and status before entering the graduate program (Figure 2). Among the student respondents, 72% were in the M.Eng. Program, while 28% were Ph.D. students. Although these two courses are geared towards M.Eng. students in MME, some non-M.Eng. students also take the courses. A majority of the respondents (78%) are not native English-language speakers, which suggests that most students are international students or maybe domestic students originally from non-English speaking countries. This proportion is consistent with the overall percentage of international students in the UWO full-time engineering graduate population. As mentioned in the previous section, the course instructor does not focus on students’ proficiency of written English when grading the project reports. However, students from non-English-speaking countries are likely to experience language barriers in understanding information literacy concepts and acquiring relevant skills and so it was important, in the analyses undertaken in the present study, to know what proportion of the student cohort were not native English speakers. Before entering their current graduate program, 33% of respondents were in an undergraduate program, another 33% were in the workforce, 28% were in another graduate program, and 6% were in a gap year.
Students were then asked what information tools they used for their course literature review project. As Figure 3 presents, all respondents used Google Scholar, and over 60% used Google or other free Web search engines. At the same time, more than 70% used library databases and slightly over 60% used reference management software, and both tools were introduced at the first library session. As for OMNI, the discovery platform, half of the respondents used it. OMNI is the university’s new discovery tool, launched in early 2020, and was introduced as a searching tool for background information and for locating full-text articles using known citation information. Less than a quarter searched journal websites for information. In addition, none of respondents used CRCnetBASE, an e-book collection, which was one of the background information resources covered in the library session. The course project did not explicitly require students to gather background information, which may explain this result. For some
students, books or handbooks might still be needed to develop a better understanding of their chosen project, such as finding relevant principles or theories. It should also be noted that books and handbooks in CRCnetBASE are also searchable via OMNI.

Students were next asked which library instruction component(s) they found helpful. As seen in Figure 4, 72% of respondents reported that library sessions helped, and half of them reported that the follow-up class visit helped. That was followed by online learning materials, like library guides or tutorials, at 56%. One third of respondents said they benefited from their preparatory work, but two thirds did not report as having benefited from this. No specific survey question was designed to seek whether the students completed preparatory work before attending library sessions. However, the responses to this question confirm that some students did their preparatory work and considered it helpful in their learning process. One third also indicated that the librarian’s assistance helped, but two thirds did not report as having benefited from this.

![Figure 4. Helpful library instruction component(s) as reported by students](image)

Regarding what content in the library instruction students found useful, Figure 5 shows that most respondents reported the following as being useful: Mendeley, library resources, and literature search strategies. Half of the respondents thought the information evaluation content useful, and 44% thought the literature review approaches useful. The data show that at least half of the respondents did not find the instruction to be useful on these two topics most closely associated with the quality of their project reports. Clearly, more effort is needed to improve and reinforce student learning with respect to information evaluation and literature review. Among the respondents, 44% found the content from the Q&A helpful, while 56% did not report as having benefited from it. The Q&A was for students to ask questions related to their own literature searching or review, and the answers were sometimes for the benefit of the whole class. Also, 39% found the content of avoiding plagiarism useful, while 61% did not report as having benefited from it.
Two questions sought the students’ opinions about their learning experiences with responses on a five-level Likert scale. One question asked about how engaged the students feel about the active learning activities included in the library sessions, and the other question asked about their overall experience with the library instruction. Figure 6 shows the results for these two questions. The responses for the first question demonstrate that the active learning activities included in the library instruction worked for most respondents, as no one chose “not engaging,” only one respondent (6%) chose “neutral,” and all the others chose “somewhat engaging,” “engaging,” or “very engaging.” Regarding the second question, all the respondents chose either “very satisfying” or “satisfying,” and none of the others. This demonstrates that the student participants felt positive about their overall learning experiences with the library instruction.

The next question invited students to share their level of understanding about the course term review project requirements. It was an open-ended question for collecting
the students’ perceptions. In the past, many students were found to have trouble carrying out the term project and could not produce a quality review paper. Those students seemed not to fully understand the expectations of the course project, although efforts were made to convey the requirements via the syllabus, project outlines, and lectures. Anecdotally, most students had no research experience, and their previous course work was mainly exam-based, which could affect their understanding of the requirements in a more open-ended project-based course. Thus, this question aimed to collect the students’ perceptions of the term project. In total, 10 students responded to this question. Most of the respondents commented that their level of understanding increased over the term for various reasons, including their development of research skills, acquisition of subject knowledge, and instructor/librarian guidance (Table 3). There were two responses that illustrated the extremes: one student commented “definitely challenging” while another respondent identified themself as having a high level of understanding due to their previous research experience.

Table 3. Student comments on their understanding of the course project requirements

<table>
<thead>
<tr>
<th>Student Comments</th>
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<tbody>
<tr>
<td>“Definitely challenging.”</td>
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<tr>
<td>“Good level of understanding.”</td>
</tr>
<tr>
<td>“My understanding towards the project was good. The resources taught during the library session were helpful.”</td>
</tr>
<tr>
<td>“It was extremely helpful to understand and learn the strategy to critique and compare different sources for about similar information. I think this way of reading a resource was a new experience for me and will not only be helpful in academic researches [sic] but also in non technical and regular readings.”</td>
</tr>
<tr>
<td>“This term project is a very good opportunity for students to learn and compare a particular aspect of thermal systems engineering. As a student progresses in the project his level of assessment and learning increases regarding that particular topic. These kind of projects help and encourage self-learning of a completely new topic.”</td>
</tr>
<tr>
<td>“The instructions were unfamiliar to begin with. However, with proper guidance and support from instructor and librarian, the objectives were well understood. The training sessions gave direction to begin our work which helped us to do things very productively. Tools like Reference management software and synthesis matrix were very helpful to find, organize and develop ideas. While skills to perform organizes [sic] research reviews has been acquired, it has also given me an opportunity to critically analyze a specific area of Energy Conversion in a way that I gained valuable and superior up to date subject knowledge. I thank both instructor and librarian for giving you prompt support when needed.”</td>
</tr>
<tr>
<td>“This course required to use some research techniques and resources available on the library homepage.”</td>
</tr>
<tr>
<td>“By comparing the related researches [sic], sections which are not clear enough, convincible enough will be criticized in the literature review. To do this, a range of studies should be read carefully, which could improve our understanding of selected specific subject. But I still found hard to give a deep suggestion to figure out the problems existing in the studies because our background of subjects are not solid enough.”</td>
</tr>
<tr>
<td>“My understanding was at a high level, but I already had a lot of scientific writing experience and was familiar/comfortable with reference managers like Zotero and Mendeley, as well as using online resources, so it wasn't anything super new to me. However, it definitely was useful for other students.”</td>
</tr>
</tbody>
</table>
Actually, I learned the method of research in this course. Furthermore, I learn [sic] to make references for my projects. basics and fundamental issues of researching is my problem which is [sic] addressed through this course.

The second open-ended question asked what changes the students would recommend for the library curriculum. In total, 10 respondents answered this question. Several respondents provided positive comments that the library instruction is “excellent,” “perfect,” “can apply to more courses,” or “was overall a good experience.” The suggestions from the students for future library instruction fall into three areas: adding more specific examples, ensuring individual students’ participation, and information access issues. Student comments are shown in Table 4.

<table>
<thead>
<tr>
<th>Student Comments</th>
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<tbody>
<tr>
<td>“More different types of examples to explain techniques.”</td>
</tr>
<tr>
<td>“Examples of term papers, different types of writing strategies.”</td>
</tr>
<tr>
<td>“Specific example of how to challenge the previous studies...what kind of criticism is qualified.”</td>
</tr>
<tr>
<td>“The progress of students should be checked at certain durations”</td>
</tr>
<tr>
<td>Ask people to upload the handout. (Note: The library handout includes a blank search strategy worksheet and the synthesis matrix for students to do their preparatory work.)</td>
</tr>
<tr>
<td>“It was overall a good experience. Ensure everybody on the same page by the time the session takes place.”</td>
</tr>
<tr>
<td>“It is perfect.”</td>
</tr>
<tr>
<td>“Explain more about finding journals that are not available using Scopus.”</td>
</tr>
<tr>
<td>“Requesting articles from the databases of other universities was very difficult, and I would like to see that become easier in the future.”</td>
</tr>
<tr>
<td>“Excellent! It can apply to more courses.”</td>
</tr>
</tbody>
</table>

Faculty Analyses of Student Project Reports

The course instructor analyzed the project reports from the 31 students in the two courses based on the instructor questionnaire. For each report, the analysis comprised an evaluation of the quality of the critical review and an assessment of the citations in the list at the end of the report that included the number of references belonging to each literature category.

Both of the courses required the students to include a minimum of 10 papers in their project reports, at least five of which should be peer-reviewed journal papers. It was found that 94% of the students met this requirement. The number of papers cited by the students varied enormously, from just 6 to as many as 77, with a mean number of 19 references. In both courses, the students were required to submit an interim progress report to which the instructor responded by suggesting how the students could improve their project work. When needed, the students were advised to consult with the librarian for relevant assistance to find enough sources. As shown in Table 1, the progress report in both courses was submitted during Week 6, approximately at the middle of the 13-week academic term. Part of the instructor feedback from the interim progress report was whether the report met the minimum number of papers requirement. This feedback may have contributed to the high percentage of students
who ultimately met the minimum requirement, as found from the assessment of the final reports. Table 5 presents the total number and percentage of referenced works in each literature category.

Table 5. Distribution of the types of literature referenced by the students in their reports

<table>
<thead>
<tr>
<th>Literature Category</th>
<th>Number</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peer-reviewed Journal Paper</td>
<td>464</td>
<td>80</td>
</tr>
<tr>
<td>Incomplete Citation in Reference List</td>
<td>30</td>
<td>5.2</td>
</tr>
<tr>
<td>Non-peer Reviewed Journal Paper</td>
<td>27</td>
<td>4.6</td>
</tr>
<tr>
<td>Conference Paper</td>
<td>24</td>
<td>4.1</td>
</tr>
<tr>
<td>Book</td>
<td>12</td>
<td>2.1</td>
</tr>
<tr>
<td>Scientific / Technical Report</td>
<td>12</td>
<td>2.1</td>
</tr>
<tr>
<td>Web Page</td>
<td>9</td>
<td>1.6</td>
</tr>
<tr>
<td>Lecture / Course Notes</td>
<td>2</td>
<td>0.3</td>
</tr>
<tr>
<td>Graduate Research Thesis</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Engineering Standard</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Patent</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>580</td>
<td>100</td>
</tr>
</tbody>
</table>

Overall, the students did very well in terms of finding quality, peer-reviewed publications relevant to their topic, with a mean of 80% of such papers being in that category (the lowest being 43% and the highest being 100%). As shown by the summary data in Table 5, a significant number of literature items (5.2%) were so poorly referenced, primarily due to their incompleteness, that they could not be categorized. Non-peer reviewed journal articles and conference papers were the next highest proportion of literature types cited. The absence of citations of graduate research theses may have been a result of the emphasis in the project briefing on peer-reviewed journal papers, whilst the absence of engineering standards and patents could be related to the fact that the critical review is related to research rather than to engineering practice or products.

The course instructor investigated what percentage of the students followed the assigned citation style in their project reports’ in-text citations and bibliographies. Overall, 35% of the students were considered to have satisfactorily provided a consistent referencing approach, with 45% having some incomplete or inconsistent references or errors in the citation, and 20% having numerous errors in their reference lists and in-text citations, with half of them (10%) producing a list of citations so incomplete and/or incoherent that it was not possible to identify most of the references to determine their quality. One issue was that some students did not check the accuracy of their citations and capitalizations after transferring references from Mendeley into their report. In terms of the three aspects: gathering information, presenting the literature review, and using information properly, the students did well in gathering information and using information properly, but did poorly in presenting the literature review.

Regarding the students’ literature review writing, most of the students’ project reports did not meet the course instructor’s expectations of the project, expressed in the project briefing document statement, that the review discussion “should be a critical appraisal of the literature, giving your own comments and evidence-based opinions on what you
have read, rather than merely copying what is written in the literature you have
gained. It should focus on the underlying science and should not simply be an author-
by-author review.” A common issue found was that the majority of students did not
demand a critical review but only summarized the literature. Few students spent the
time extracting information from different papers and bringing it together in their own
graphs and tables for review; while many others wrote an unnecessarily lengthy paper
with information, like text, figures, and tables, extracted from the papers without
providing their own intellectual work, such as analysis and evaluation. Thus, the course
instructor considered imposing a page limit on each section of the term paper for future
cohorts. Other issues included a lack of focus, an absence of a discussion of the basic
engineering science relating to the problem being studied, a failure to synthesize
information from the literature, and a lack of critical evaluation of the published work
in terms of the research method(s) and the results obtained. The failure to synthesize
information from different sources was partly attributable to the students not being able
to sufficiently narrow the scope of their literature searches to find papers with enough
commonality at the detailed subtopic level, despite their success in searching at the
broader topic level. For example, few students were able to find two or more
publications on closely related studies where, across those publications, either the same
subtopic was examined using similar or different research methods or different
subtopics were researched using similar methods.

In addition, 32% of the students cited 24 or more papers and only 20% of those students
subsequently produced a quality critical review, indicating that many of the cited
papers: (a) were not read by the student, (b) were citations from secondary sources
rather than the original source publication, or (c) even if read, were not critically
analyzed or synthesized. The mean grade given to the critical review section of the
student reports was 72%, ranging from 49% to 100%. Overall, in the opinion of the
instructor, 19% of the students produced a quality critical review (represented by those
receiving a grade of 83% or above). In all these cases, with only a few minor errors, the
referencing was exemplary. Whilst the poorest performing students also referenced
poorly, there were also many students who were exemplary in their reference list and
in-text citations but were unable to produce a quality critical review. This suggests a
significant gap between the students’ ability to find and access information and their
ability to synthesize and critically evaluate that information.

Using information properly is an important topic in academia. The plagiarism topic was
delivered in the second library session for both courses in 2019-2020. No obvious cases
of plagiarism were observed in the project reports. However, there was a common
mistake: many students did not cite the sources in the caption of their reproduced
figures from papers. This finding informs the need to include how to cite data sources
in future library instruction. In addition, as mentioned, some students might take the
citation of papers cited by others but not obtained or read by them, judged by their
project reports.

The following changes are recommended to the library curriculum for these courses
due to the problems identified. Although the course instructor included the required
report structure in the course project outline, it is clear that students require
significantly more detail regarding the structure of a report. For example, 61% of the
students either did not include a nomenclature section at all, or provided one that was far from complete, even though the report content and structure section of the project briefing document stated that the report should include a complete list of all the variables used in the report. Hence, the library instruction should place more emphasis on academic report structure. Issues such as referencing of all factual comments made by the student in their report, referencing of figures and tables and only citing primary sources that they have read themselves, should also be highlighted in the revised library instruction. It is also clear that the majority of students (about 80%) had trouble understanding what is expected for a critical review and how to distinguish between summarizing information and conducting a review, and so performed unsatisfactorily. Therefore, a class exercise is necessary to help students develop their critical thinking skills so that they can effectively evaluate and critique information from papers to meet the requirements of a critical review. The current literature review activity in the library curriculum is helpful in this aspect, but many students were found to lack preparation for the library sessions, which calls for more effort in ensuring students’ participation.

Reflections and Future Improvements

First of all, there is a need to further balance the library instruction load among the three class times, as still too much content had been assigned to the first session. Students might have experienced cognitive overload in that session while the two other class times were not as well-used. In addition, the timing of the first session would be unsuitable for teaching some topics that would make more sense to the students later as their project work progressed. Thus, the librarian and the course instructor decided to spread the information literacy topics over the three class times in future iterations.

Many students did not make good use of the course materials posted on the institution’s course management site (OWL) based on their communications with the course instructor and the librarian. One extreme example was a student who did not know of the existence of the project outline even after the middle of the term. Given that many of the students appear to be coming from outside the Canadian higher education system, based on the survey responses, they may be less familiar with the intensive use of the institutional learning management system at UWO. This would also affect their preparation for library sessions as the lesson plan and relevant library materials were uploaded to OWL and nowhere else. More emphasis is needed at the beginning of the term regarding the use of OWL for accessing learning materials.

Most students had no experience with research or literature reviews and so they found the course project challenging. Anecdotally, some students preferred the course-based rather than the research-based masters program, as it meant they could avoid doing research and writing papers. It is clear that additional context and rationale is needed so that the students understand why they are being required to engage in a writing-intensive project in a “course-based” program. As stated earlier, many of the students are unfamiliar with the Canadian educational system and may be unaware of the significance of using library resources in their coursework. It is necessary to help students break down their misunderstandings about scientific writing and information literacy. This concurs with the literature recommending that academic librarians should integrate transformative learning into their teaching practice and help students cross
the thresholds in their learning process, as guided by the ACRL Framework (Alpi & Hoggan, 2016; Hooper & Scharf, 2017). In future iterations, the librarian will allot appropriate class time for explaining “why” instead of purely working on the “how” and will refer to the guidelines related to information literacy and life-long learning from professional engineering associations, such as PEO. This way, students can see the profound impact of information skills on their future careers, not just their current course or program, which might better engage them in learning these skills. In addition, further work is needed to develop tools for educating students on how to integrate critical thinking and analysis in their project reports beyond merely summaries of the literature.

As mentioned previously, the current study did not investigate what percentage of students completed their preparatory work for library instruction. However, some students found their preparatory work helpful, and a few even suggested that this work, such as the literature search strategy worksheet, should be submitted to ensure that everyone is on the same page for the in-class learning. To encourage students to complete their library preparatory work, the course instructor assigned a small percentage (5%) of the course grade to two parts of the preparatory work for the following iteration of MME 9641 Thermal System Engineering (2020-2021): one was the Search Strategy Worksheet and the other was the Synthesis Matrix. The grading was expected to serve as a positive incentive for students to do the assignments. As a result, most of the students did a satisfactory job with these two assignments and were engaged in the associated class activities, which was encouraging.

Limitations

The authors identified the following limitations of the present study. First, as mentioned earlier, the study is a small-scale case study due to the course enrollment, so the findings may not be generalized. Some of the issues, such as students’ lack of critical thinking skills, identified in this study have existed in these courses for years, which may be representative in project-based engineering graduate courses. Second, the research instrument may not fully answer the first research question, “What are the information needs of engineering graduate students in a project-based course?” The information collected from student survey responses and faculty analyses of the project reports reflects student information needs for their course project. However, it may be more insightful if the student survey asked about information needs using open-ended questions. Third, the information about students' prior knowledge of information literacy and scientific research is not collected. This information would help the course instructor and the librarian better understand student performance in the project-based courses and adjust their teaching accordingly. From a constructivist perspective, the learner’s prior knowledge works as a foundation upon which new knowledge can be built (Piaget, 1968). Research shows that “prior knowledge can help or hinder learning,” therefore educators should identify and address common misconceptions that affect how students acquire new knowledge, which will lead to improved teaching effectiveness (Ambrose et al., 2010, p. 13).
Conclusion

This study explores engineering graduate student information needs for their term research review project and evaluates their learning experiences with information literacy instruction. The findings show that many of the students reported using the tools presented in the library instruction, several of the elements of library instruction were reported as useful by a majority of the students, and almost all of the students met the requirement of finding quality, peer-reviewed publications. However, many students were found to have summarized, rather than critically reviewed, the literature in their project paper, even though the initial written and verbal project briefing provided information concerning what is meant by a critical review. The study sheds light on what improvements should be made to information literacy instruction that will enhance student learning and meet the expectations of project-based courses at the graduate level. The faculty-librarian collaboration is demonstrated as being essential in aligning library instruction with program or course learning outcomes. This study demonstrates the value of librarians incorporating faculty and student feedback into their instructional planning and continuously adapting their teaching practice.

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References


Appendix 1: Online Survey to Student

Q1. Are you a/an __________ student?
   □ M.Eng. (course-based)
   □ M.E.Sc. (research-based)
   □ Ph.D.

Q2. Is English your native language (or one of your native languages)?
   □ Yes
   □ No

Q3. Are you entering your graduate program from:
   □ Undergraduate program
   □ Other graduate program
   □ Work force
   □ Gap year

Q4. What information tools did you use for your term research review project in this course? Select all that apply.
   □ OMNI, the library catalogue
   □ CRCnetBASE
   □ Databases, e.g. Scopus, Web of Science
   □ Google Scholar
   □ Journal websites
   □ Mendeley or other reference management software
   □ Google or other free Web search engine

Q5. Which library instruction component did you find helpful? Select all that apply.
   □ Online learning, e.g. library guides or tutorials
   □ Prep work prior to library session
   □ Library sessions
   □ Follow-up class visit
   □ Library help from the librarian, e.g. one-on-one consults, email reference

Q6. What content in the library instruction did you find useful? Select all that apply.
   □ Library resources
   □ Literature search strategies
   □ Mendeley, a reference management tool
   □ Theme-based approach for literature review
   □ Information evaluation
Q7. The library instruction included a list of active learning activities (e.g. hands-on exercises, group discussions). How engaging were these activities?

- Very engaging
- Engaging
- Somewhat engaging
- Neutral
- Not engaging

Q8. Your overall experience with the library instruction is:

- Very satisfying
- Satisfying
- Somewhat satisfying
- Neutral
- Not satisfying

Q9. Please share your level of understanding about the requirements of this course’s term research review project.

Q10. What changes would you like to recommend for the library instruction in this course?
Appendix 2: Questionnaire to Instructor

Q1. Roughly what percentage of the students meet the requirements to include a minimum of 10 papers in the project report, at least 5 of which should be peer-reviewed journal papers?

Q2. Are you satisfied with the overall quality of the scholarly sources included in the project reports submitted by the students? Why or why not?

Q3. For the students’ project reports, do you find any problems with their writing of literature review? If yes, please describe the problems.

Q4. Do you discover any plagiarism cases in the project reports? If yes, how many cases in total? Could you share any details?

Q5. Roughly what percentage of the students followed the assigned citation style in the in-text citations and bibliography of their project reports?

Q6. In general, how satisfied are you with the students’ project reports, in the following aspects: gathering information, presenting literature review, and using information properly?

Q7. What changes would you like to recommend for the library component of your course?

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